PALEONTOLOGY.—*New Carboniferous invertebrates*—IV.[1] GEORGE H. GIRTY, U. S. Geological Survey.

This paper contains descriptions of one brachiopod from western Texas, five gastropods from Colorado, and three gastropods from Arkansas.

Cryptacanthia? robusta n. sp.
Figs. 1–7.

Shell rather large for the genus, subpentagonal in outline, highly inequivalve with reversed curvature, the pedicle valve having a pronounced fold and the brachial valve a pronounced sinus.

The pedicle valve is widest at the mid-length or just above and somewhat emarginate in front with an outline more or less conspicuously pentagonal. Longitudinally, this valve is gently arched toward the anterior end, but shows a rapidly increasing curvature toward the beak which rather strikingly overhangs the brachial valve. Transversely, the median part is more or less planate at the anterior end, the flattened zone contracting posteriorly to form a narrowly rounded ridge which terminates in the small incurved beak. From this flattened median part the lateral slopes descend steeply and to an uncommon length, causing the valve to be correspondingly convex. The lateral slopes are flattened or even somewhat concave and they seem to flare slightly in the region of the cardinal angles. On some specimens the descent from the fold is so abrupt close to the anterior margin as to produce two short but pronounced grooves and to give that structure, which would otherwise be undefined, distinct boundaries and a quadrate shape. The beak in my specimens is imperfect but it appears to have been truncated by a round foramen without any collar formed by the introverted shell margin adjacent.

The brachial valve is subquadrate in outline and moderately convex. It is strongly and more or less abruptly deflected at the sides and across the front, leaving a median area (for half or two-thirds of the length) which is but slightly arched. The sinus, which makes its appearance back of the middle of the valve, is in the beginning a narrow groove, but it widens rapidly and somewhat abruptly, the bottom, at the same time, becoming more rounded and at the anterior margin almost planate. There, the part included in the sinus projects as a linguiform extension which is folded downward at a strong angle, one, however, appreciably greater than 90 degrees. The parts on either side of the sinus are also deflected downward, though less strongly than the sinus itself, with an almost truncating effect. As an extreme expression this valve is planate over the posterior part and abruptly flexed along three sides, so that the planate area has a certain definition. The lateral and anterior folds in conjunction with the broad deep sinus, cause this area to terminate on either side in prominences almost like little mounds.

Of internal structures little is known except that the pedicle valve is provided with dental plates and the brachial valve with a strong median septum. The shell substance is finely punctate.

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C. robusta so closely resembles *Cryptacanthia compacta* as to raise a doubt whether it is more than a very robust form of that species, yet the facts regarding both are so incompletely known and in certain respects so at variance as to suggest that they belong to distinct genera. The possibility that they belong to different genera is opposed by their close external similarity. Such a resemblance would mean little or nothing between many species but in this instance it is significant because the configuration which these two possess in common is highly exceptional and distinctive. On the other hand, the original description of *C. compacta* does not mention the dental plates and median septum which are shown by the present species, and it does give the character of the brachidium whose characters in the present species have not been determined.

C. compacta is one of the rarest of Carboniferous brachiopods and no first hand description of it has been published since 1868 until very recently. Dunbar and Condra, however, redescribe the genus with some additional characters among which, significant in the present connection, are the presence of dental lamellae in the pedicle valve (a character which could be predicated with reasonable assurance as it is found in all or nearly all Carboniferous Terebratuloids) and the absence of a median septum in the brachial valve. I hesitate to challenge the character last mentioned and at the same time cannot accept it unconditionally for the following reasons. I have examined specimens of *C. compacta*, especially one from the Murphysboro quadrangle (station 6129) in which a median septum certainly appears to be present, though it may not have the form of a thin high plate. Furthermore, the specimen which supplied the structural characters described by Dunbar and Condra and which in their sections seem to afford conclusive evidence that a septum was absent, came from New Mexico and is strikingly unlike the authentic specimen shown by the original publication. Their figures (p. 309) represent a shell that is much more elongate, that is ovate in outline instead of pentagonal, and that has a moderately convex instead of a nearly flat brachial valve. On these grounds one might infer that their specimen did not belong to *C. compacta* and might not belong to *Cryptacanthia* at all. These differences are less marked, however, if the figures on p. 309 are compared with figures on plate 37 representing specimens from Kansas and Illinois. The fact that a median septum was not mentioned in the original description cannot be taken as corroborating the observations of Dunbar and Condra for the original description also failed to mention the much more obvious dental lamellae.

If *Cryptacanthia* did indeed lack a median septum in the brachial valve, the present species can hardly remain in the same genus as *C. compacta.* In the presence of this septum it suggests the genus *Heterelasma*, not to mention *Girtyella* and others, but in configuration it is the reverse of *Heterelasma* whose characters in this category are singularly misrepresented in the American Zittel. In that usually accurate work the genus is summarized as

comprising "smooth Dielasmids with a ventral fold and a dorsal sinus." In point of fact, the transverse curvature of the ventral valve in *Heterelasma* is concave, in other words, it has a sinus not a fold, and that of the brachial valve is convex, but the convex curvature is reversed in the anterior part which is indented by a more or less conspicuous sinus. The present species which really has a fold in the ventral valve and a sinus in the dorsal valve might well belong in *Heterelasma* as the genus is represented in Zittel, but not as it is in fact. If it does not belong in *Heterelasma* by reason of the reversed curvature of the valves, or in *Cryptacanthia* by reason of the median septum in the brachial valve, its generic affinities are hard to discover. In configuration it recalls the Jurassic genus *Glossothyris* and in default of a suitable generic locus the term *Glossothyropsis* might be used for it.

In its specific relations as already pointed out *C. robusta* greatly resembles *Cryptacanthia compacta* and when the doubtful points are cleared up, it may belong in the same genus. As a summary of the differences at present known, aside from those of generic significance, *C. robusta* is much larger; the lateral outlines appear to contract more gradually forward so that the anterior outline is broader than it is in *C. compacta;* the two valves appear to be much less unequal in convexity, the pedicle valve being somewhat lower and not so angular along the median line, and the brachial valve not quite so planate; and the fold and sinus are higher and conspicuously quadrate in outline. These differences can not be wholly vouched for, as the original description and figures of *C. compacta* are inadequate in several respects, and as specimens are rare. I have been able to examine only 10 or 12 specimens, all of them small and more or less broken. Their imperfections tend to vitiate the identification, but it is probable that they belong to *C. compacta*. The fact that *C. robusta* occurs in a widely unlike fauna of much later geologic age adds significance to the differences already known and gives promise of others when our knowledge is more complete.

C. robusta occurs associated with *Pugnax bisulcata*, which it resembles so closely in configuration that on a hasty examination the two species might readily be confused; the resemblance, of course, is only superficial and scarcely that, inasmuch as it exists only through a reversal of the valves, the pedicle in this species resembling the brachial valve in that and vice versa.

Delaware Mountain formation (Permian); True Canyon, 7 miles northwest of 7-Heart Gap, Culberson County, Texas (station 6452).

Pleurotomaria worthenioides n. sp.

Figs. 8, 9.

Shell small, conical, turreted, consisting of 5 or 6 volutions. Apical angle less than a right angle but varying with different specimens. Aperture rhombic. In the final volution the peripheral region is occupied by two large rounded carinae which inclose between them a flattened and much depressed

zone containing the slitband. The lower of the two carinae is almost basal and is slightly smaller and less prominent than the upper. The surface between the suture and the upper carina is broad, strongly oblique, and nearly flat though it is slightly tumid near the suture and more or less spreading as it joins the carina. The lower surface is gently convex and nearly horizontal except that near the axis it bends strongly upwards. The whorls embrace up to the lower carina which is concealed in some specimens and partly exposed in others. The upper carina on the other hand forms a conspicuous projection and lends the shell its turreted appearance. The axis seems to be imperforate.

The lateral surface is marked by 6 or 7 fine, sharp, revolving lirae which diminish in size from above downwards and are separated by interspaces wider than the lirae themselves. About 4 similar lirae, but finer and more crowded, occur on the upper carina and two or three others like them on the lower carina. The lower surface is marked by about 10 revolving lirae which are coarser and stronger than those of the lateral surface, and stand rather more than their own diameter apart. The interspaces gradually diminish toward the axis and the lirae decrease in size and strength in the same direction. The sculpture also comprises fine, regular lamellose transverse lirae. On the lateral surface they decrease in size individually from above downward and are perhaps a little more delicate than the revolving lirae and possibly a little more closely arranged. They form with the revolving lirae a regular cancellated sculpture marked at the intersections by minute but conspicuous nodes. The transverse lirae are well developed upon the upper carina, cancellating the revolving lirae that occur there, and they reappear on the lower carina. Over the basal surface they are a minor feature. If well developed or well preserved they are sharp and clear, but much more delicate and much more closely arranged than the revolving lirae which they cross as crenulations rather than as nodes. The slitband occupies nearly the whole of the depression between the two carinae and is defined by lamellose lines partway up its sides. The slitband is divided longitudinally by a slender revolving lira set with minute, closely arranged, uniform nodes, whereas each of the divisions is subdivided by a lira more or less inferior in size. In the slitband the transverse lirae appear as delicate close-set lunettes which on many specimens are somewhat difficult to make out and are chiefly apparent by reason of the nodes that they produce in crossing the median lira.

On the lateral surface the growth lines have a strong backward trend from the suture and a slight convexity toward the aperture. In crossing the slitband of course they are conspicuously arched with the convex side facing backward. On the lower surface their general direction is about transverse but they retreat into a broad shallow concave arc just below the lower carina and make a short shallow convex arc in the axial region.

This species is not exactly rare; about 25 specimens, large and small, have been examined, but only a few of the large ones are well preserved, whereas the small ones are identified with less accuracy. Some of the variation observed is probably due to imperfect preservation. That the revolving lirae vary somewhat in number and arrangement scarcely need be specified. In some specimens revolving lirae seem to be obsolete on the carinae, the transverse lirae alone being distinguishable. The carinae then appear flat on top instead of rounded. The delicate though sharp lunettes in the slitband are

more often invisible than seen, and the transverse lines of the lower surface may be sought for in vain. Probably they are fully developed, but are subdued to the strength of growth lines, or obscured by abrasion. On a few small specimens from Woolsey, Ark. (station 2849) the upper carina is uncommonly thin and prominent.

Brentwood limestone member of the Bloyd shale (early Pennsylvanian); SW$\frac{1}{4}$ sec. 27, T13N, R32W, Winslow quadrangle, Arkansas (station 3733).

Euconospira hermosana n. sp.
Figs. 10–12.

Shell small, conical, composed of about seven gradually enlarging volutions. The spire comprises half, or a little more than half, of the entire height, and the height is slightly greater than the width of the last volution.

Final volution somewhat rhombic in section and strongly carinated around the periphery which is at the mid height or somewhat below. The lateral surface, which is slightly concave, descends steeply from the suture. The lower surface, which is gently convex, descends from the periphery inward, but in the axial region it rather sharply assumes an upward direction. The peripheral zone is occupied and truncated by the slitband, which is rather narrow and depressed between two thin strongly projecting lamellae. Below the carina, that is, on the lower surface but in the peripheral part, there is a narrow groove which in width is about equal to the slitband, and which is separated from the slitband by the lower of the two bounding lamellae; below this again and of about the same width there is a narrow, rounded ridge. The volutions embrace to this spiral ridge, so that the carina forms a somewhat conspicuous projection winding around the shell, but losing its elevation as it approaches the apex.

The surface is crossed by numerous slender, sharply elevated transverse lirae distinctly narrower than the striae between them, little difference in sculpture being observable between the lateral and basal parts. On the upper surface these lines are at the same time convex (toward the aperture) and oblique, with a rather strong backward swing. On the lower surface they are sinuous but on the whole generally transverse in direction. Starting at the slitband they have for a short distance a forward direction but turn backward as they cross the revolving ridge on the basal surface. Thence, they make a broad shallow reentrant curve, followed by a broad shallow convex curve, the change in direction occurring about midway on the lower surface. As these lines necessarily converge toward the axis, many that begin at the carina die out or become confluent to form lirae of larger size; the others apparently become somewhat strengthened so that the peripheral half of the lower surface is more finely striated than the axial half. In the slitband the transverse lines make distinct lunettes, the markings here being similar to those elsewhere on the shell but considerably finer. Traces of extremely fine spiral lines have been observed in the slitband. They are interrupted by the lunettes or confined to the spaces between them. Some 5 or 6 of the transverse lirae of the upper surface are spanned by 1 mm., the measurement being made at right angles to their oblique direction. On the lower surface the liration is somewhat finer near the carina but it becomes as coarse if not coarser toward the axis through confluence or fasciculation of the lirae.

In typical *Euconospira* the surface is crossed by spiral as well as trans-

verse lines, producing a cancellated ornamentation. *Euconospira Hermosana* has no such spiral lines, and this fact although it is not regarded as debaring it from *Euconospira*, at once distinguishes it from a number of species there referred. Several species of *Euconospira*, it is true, have only traces of spiral lines (such as the very robust *E. taggarti*), or have spiral lines only on the under surface. *Pleurotomaria coniformis*, *P. conulus*, and *P.* (*Bembexia*) *elegantula*, which possibly should be referred under *Euconospira*, have, like the present species, only transverse lirae, but they are sharply distinguished from it in other ways.

McCoy formation of Roth (Pennsylvanian); McCoy, Colorado.

Pleurotomaria rockymontana n. sp.
Figs. 13–16.

Shell of moderate size, elongate, conical, composed of 10 or more gradually enlarging volutions. Spire about twice the height of the final volution and distinctly but not strongly turreted.

Final volution irregularly rhombic in section with the basal surface gently convex and almost horizontal, with the lateral surface strongly oblique, and with the carinated periphery sharply rounded or subtruncate. The lateral surface is slightly sinuate, somewhat protuberant in the upper part and somewhat flaring in the lower. The peripheral angle, which is rounded as just described, is the locus of 2 revolving ridges or carinae of which the higher is slightly the more prominent. Adjacent to the lower carina, but on the underside of the volution is a third ridge distinctly inferior in size and prominence. It is separated from the lower carina by a narrow groove, somewhat narrower and shallower than the groove inclosed between the two peripheral carinae.

The lateral surface of the final volution is crossed by small spiral and transverse lines which form a regular and fine cancellation marked with little nodes where the lines intersect. The spiral lines are slender and spaced at about their own width or somewhat more. They are subequal but gradually diminish in size and prominence from above downward. About 8 can be counted on one specimen; one or two more on others. The transverse lines are about the same in size and spacing as the spiral ones on some specimens but on most they are the dominant feature being conspicuously stronger and more widely spaced. They are in the upper part almost straight and almost direct but bend backward more or less strongly as they approach the upper carina so that they have, in that degree, a general backward trend.

The markings of the peripheral zone vary much in detail on different specimens, probably due to the minute character of the units and to their imperfect and unequal preservation. Where most clearly distinguishable the slitband is a narrow flat ribbon deeply depressed between the two peripheral carinae. It appears to be defined by delicate lirae on the sides of the carinae and it is marked by very fine, closely arranged lunettes. The occurrence of the lirae is such that the carinae sometimes appear to be surmounted by two revolving lirae. This is especially true of the lower carina because it is somewhat smaller and less prominent than the upper, and the lira on its inner side is more on a parity with it. In one specimen the slitband is not distinguishable as such, but instead the groove between the carinae appears to be occupied by several fine spiral lines. These features are not shown clearly or

in detail, however. The transverse lirae apparently do not pass the upper carina, which is not crenulated, and when they reappear in the slitband they are very much finer and more closely arranged. Nor have they been detected on the lower carina, but in the groove just below it the transverse lines reappear with a sharp expression and with a marked forward slant from above. Traces of fine spiral lines are also shown here by some specimens, and probably they are a constant feature. The sculpture of the basal surface from the lower carina to the axis, is not well shown. It seems to be cancellated like the lateral surface, but more finely. The revolving lirae are more slender, more closely arranged and consequently more numerous, and the transverse lines are even finer. They are greatly inferior to the transverse lines of the lateral surface so that whereas there the transverse lines are the dominant feature, the spiral lines have here the dominant part. The volutions embrace so as partly to conceal the lowest of the three revolving ridges that occupy the peripheral zone exposing, however, its crest together with the groove above it and the two peripheral carinae with their included groove. These projections break the regular slope of the spire and give the conical shell its somewhat turreted shape.

This species appears to resemble *P. adamsi* in a general way. Worthen's description, however, is not clear, in fact seems to be contradictory regarding certain details. In point of sculpture it mentions only spiral lines on the two carinae which inclose the slitband. One part, at least, of the final volution is said to be smooth, apparently the basal surface ("smooth below the spiral band"); this is not true of any part of *P. rockymontana*. *P. adamsi* also has a wider spiral angle. *P. giffordi* is on the whole somewhat more similar but it has fewer spiral lines on the lateral surface and apparently no transverse lines at all; there are other differences as well, such as showing a greater depth of shell below the slitband in the final volution and above the suture in the higher ones and lacking a third ridge below the two carinae that inclose the slitband. *P. subdecussata* and *P. rockymontana* are also comparable in a number of details, more in sculpture than in configuration, as *P. subdecussata* has a much lower spire. *P. subdecussata* resembles the present species and differs from the two previously mentioned, in having the lateral surface finely cancellated by numerous revolving and transverse lines, but like the foregoing it appears to lack the additional carina below the two on the periphery.

McCoy formation of Roth (Pennsylvanian); McCoy, Colorado (station 6714).

Orestes? reticulatus n. sp.
Figs. 17–19.

Shell rather small, subconical, composed of about seven volutions. Width and height nearly equal.

Final volution rhombic in section with the peripheral line well-nigh basal. The lateral surface juts out at the suture to form a narrow shelf-like projection which, though slightly inclined is almost horizontal. From this tablet, which it meets in a pronounced angle, the main part of the lateral surface, sloping steeply, drops down to the periphery without material interruption.

The peripheral angle, which is about 60 degrees, is somewhat truncated or sharply rounded. The lower surface is almost planate and almost horizontal. It descends appreciably from the peripheral angle and in the axial region makes a sub-angular turn, bending upward with a slight obliquity. The axis is solid and the lip slightly reflexed to form a false umbilicus. The rather broad slit band occurs just above the periphery and is sharply defined by two rather thick prominent lirae. Just below the lower of these lirae but still above the peripheral line the surface retreats into a rather narrow deep rounded groove, and this is followed by the periphery itself, consisting of a narrow rounded ridge which in width is about equal to the groove above and in prominence scarcely exceeds the guarding lirae of the slitband. Thus the peripheral region is marked by three slender ridges or carinae separated by two grooves. The lower carina is decidedly thicker than the two above that inclose the slitband, and the slitband or upper groove is much broader than the lower. The volutions embrace up to and including the lowest ridge, so that the groove above and the slitband are exposed. This gives the shell as a whole an obscurely turreted appearance. As the whorls are followed backward up the spire, they lose their angulated shape and become more regularly rounded.

The sculpture in general terms consists of a rather coarse reticulation made by sharply raised revolving lirae crossed by transverse lirae of about the same size and spacing. Small but rather conspicuous nodes emphasize the points where the lirae intersect. Reckoning the sharp edge of the shelf-like projection below the suture as a lira, from 6 to 8 revolving lirae occupy the lateral surface and an additional lira not uncommonly occurs upon the subsutural tablature. The lirae are as a rule rather regular in size and spacing, but they may vary greatly, and in both items they show a general diminution downward toward the slitband. The two slender lirae that inclose the slitband are not distinguished from the lirae above except that they are a little more prominent and are not affected by the transverse lirae. They are smooth or in places finely notched or crenulated. Two rather small spiral lines close together form the peripheral curve or carina (wherefore its rounded instead of angulated shape) and from 10 to 13 others are developed on the lower surface. This part of the shell is somewhat more finely marked than the lateral surface, the lirae being more slender and the intervals narrower, though on both surfaces the intervals are decidedly wider than the lirae. The slitband generally appears to be without spiral lines and to be marked only by the usual lunettes, but in one specimen the slitband is divided by a single delicate raised line, and in several it shows traces of numerous exceedingly minute lines which seem to be interrupted by the much stronger lunettes and confined to the intervals between them.

The transverse lirae on the lateral surface are about like the spiral lirae, rather strong and coarse, and between the two, the lateral surface is divided into rather large rhombic areas. The transverse lirae come to an end at the raised line that forms the upper boundary of the slitband. They are not continuous with the lunettes in the slitband which are in fact much more numerous and more closely arranged. Nor do they account for the crenulations on the lira that bounds the slitband above (when these can be seen at all) for the crenulations are even finer than the lunettes. On the lower surface the transverse lirae are generally finer, more subdued and more closely arranged than they are on the lateral surface. They show considerable irregularity on the same specimen and great variation between different speci-

mens. Compared with the revolving lirae which they intersect, they are less conspicuous; they are also more closely arranged so that the parallelograms which they help to inclose are much longer than they are wide. Here on the lower surface they are associated with growth lines to which they are similar in kind but superior in strength.

In direction, the transverse lirae spread straight out from the suture, but take on a slight backward trend at the angular margin of the tablature that surrounds it, and at the same time they become arched (convex side toward the aperture), so that upon reaching the upper boundary of the slit band their backward direction is very pronounced. The transverse markings on the slit band itself make the usual concave arch. On the lower surface the transverse lines have a gentle backward trend from the periphery and are gently sinuous in shape. Close under the slit band they have a forward direction, but, making a turn on the periphery they first describe a concave curve and then when half-way across, a convex curve. These curves, which are expressed with reference to the outer lip, are very broad and shallow.

In some respects *Orestes*? *reticulatus* resembles the species which Keyes thought might be the one which Meek and Worthen thought might be Shumard's *Pleurotomaria brazoensis*. Shumard's species, as I interpret it on specimens from Texas, is a characteristic member of the genus *Orestes*, and is very different from Meek and Worthen's shell. The latter must be called *Pleurotomaria intertexta*, a reversional name which those authors suggested in case it proved to be distinct from *P. brazoensis*. *P. brazoensis* of Keyes, on the other hand, seems to be a quite different species from the *P. brazoensis* of Meek and Worthen (or *Pleurotomaria intertexta*) and even more different from typical *P. brazoensis*. Though not identical with *Orestes*? *reticulatus*, it is much like it in general appearance. Its shape, however, is more turreted and less conical; its slit band is broader, is divided by a median line, and is peripheral in position instead of being above the periphery with a groove below it. The carinae on either side of the slit band are not simple raised lines or ridges—they are compound, the upper being formed by two raised lines and the lower by two or three. Furthermore, the transverse lines are of two orders and so disposed that from three to six of microscopic size intervene between two of the larger ones. Something like this can be observed on the lower surface of *O. reticulatus* though the intermediate lines are subdued and incremental in character, but on the lateral surface, growth lines, if present at all, are only just discernible. Thus, the obvious resemblance between *O.*? *reticulatus* and the *Pleurotomaria brazoensis* of Keyes is of a general character, and critical comparison discloses many differences in detail.

McCoy formation of Roth (Pennsylvanian); McCoy, Colorado (station 6714).

Orestes? quadrilineatus n. sp.
Figs. 20–22.

In its general character and also in many details this species is closely allied to *Orestes*? *reticulatus*. It is, however, more depressed and in shape more

or less hemispherical whereas the other is more or less conical. This difference is partly due to the shape of the constituent volutions which are more rounded, and partly to their adjustment to one another. The more rounded shape of the volutions manifests itself in several details. The lateral surface is more arched and at the same time less oblique; the lower surface likewise is more arched, dropping farther below the peripheral zone. The peripheral zone is much less angular, for whereas in *O.? reticulatus* the part below the slitband projects beyond the part above, so as to form a sharply rounded peripheral angle, in this species the two parts project about equally, so that the slitband appears to occur rather upon a broadly rounded peripheral zone than above a narrowly rounded one.

The two species differ perhaps more in configuration than they do in sculpture, but the sculpture too, though the same in general character, is different in certain details. The spiral ornamentation in *O.? quadrilineatus* consists of fewer and sometimes thicker lines more widely spaced and the transverse ornamentation also, though varying greatly in scale, is on the whole somewhat coarser. The lateral surface is commonly marked by 4 strong, sub-angular, revolving costae separated by rounded grooves of much larger size. This enumeration does not include the raised line that bounds the slitband on its upper side, but it does include the ridge that marks the outer limit of the tablature below the suture. These four revolving costae can not be said to have any constant or characteristic arrangement for they vary in spacing from specimen to specimen, but rather commonly the upper one stands some distance from the suture and the intervening surface may, by reason of the rounded shape of the volution, incline slightly downward toward the suture instead of declining slightly away from it. On the other hand the side of the surface may arch inward regularly to the suture without forming any distinct tablature. The lowest of the 4 costae, as a rule, occurs rather close to the slitband, but is separated by a rather broad interval from the one above. The one above (or the third from the suture) may be somewhat smaller than the rest or it may be entirely undeveloped. In that event there would be 3 instead of 4 of these revolving costae. All four, however, may be essentially equal in size and spacing. The transverse lirae instead of tracing a regular backward curve from the suture as in *O.? reticulatus*, reach the same end by an angular change of direction where they cross the spiral ridges, the points of intersection being marked by nodes which though actually small are sometimes prominent and striking. Thus, the shelf-like jutting of the shell below the suture is apt to be conspicuously and handsomely marked by strong lines which spread out from the suture, form pronounced nodes on the revolving ridge that forms its outer boundary, and pass backward by successive angles to the slitband. This shelf-like projection, crossed by transverse lines and bordered by a row of nodes, is in many specimens a conspicuous feature.

O. quadrilineatus is closely related to *O. reticulatus;* the fact of relationship is clear and the degree is not. Taken together a rather large number of specimens have been examined but many of these specimens have been crushed, some completely flattened, so that their original shape at best can only be surmised; to that extent it is impossible to determine how far the differences in configuration and the differences in sculpture above described are parallel developments, especially as the sculpture also is defaced in some specimens.

Judged by such specimens as retain both features more or less faithfully the two species appear to intergrade. Some specimens represent a more or less intermediate condition between the low hemispherical shape distinctive of *O. quadrilineatus* and the high conical shape distinctive of *O. reticulatus.* Again some specimens that in configuration appear to belong with the one species have a sculpture tending to ally them with the other. In fact the sculpture is not at all constant, varying if only in minutiae from specimen to specimen. Yet we have the counter-vailing fact that the low hemispherical shells do generally differ in sculpture as well as in shape from the high conical ones and that the extremes are conspicuously unlike.

McCoy formation of Roth (Pennsylvanian); McCoy, Colorado (station 6714).

Pleurotomaria aspera n. sp.

Figs. 23–25.

Shell small, conical, composed of 6 or 7 regularly enlarging volutions. Spiral angle about 60°. Spire with rather flat sides interrupted by the suture which is indented though not deeply.

Final volution trapezoidal in section with the peripheral line almost basal. The lateral surface is nearly planate, descending steeply from the suture and passing below into the peripheral angle which is narrowly rounded. The basal surface, though nearly flat and nearly horizontal descends slightly from the periphery and bends upward rather abruptly in the axial region. The slit-band is situated on the peripheral angle and the volutions embrace to or almost to its lower boundary. The axis is solid, but the lip appears to be slightly reflexed forming a small indentation.

The sculpture, as is usual in these shells, consists of spiral and transverse lirae but as the lirae are uncommonly strong and coarse for so small a species they give the surface a conspicuously rough appearance. The side of the last volution is marked by 5 or 6 primary lirae which are more or less equal in size and separated by somewhat wider interspaces. The interspaces, like the lirae, vary somewhat in width and one or more of them may be occupied by a secondary lira; thus the sculpture presents great variety in detail. The transverse lirae are not quite so strong as the revolving lirae and they are not quite so far apart. The intersections of these decussating lines are marked by exceptionally large nodes. The nodes are somewhat elongated in line with the transverse lirae which are thin and depressed in the intervals between them. Thus the nodes have a strict linear arrangement in a transverse as well as in a spiral direction. This double alignment is not well shown in the illustrations in which the transverse arrangement is hardly distinguishable while the spiral arrangement is conspicuous. The transverse lirae at the outset are about perpendicular to the suture but in a short distance they bend rather abruptly backward with a gently convex course. The slitband is broad. It is divided by a median lira which is generally stout and strongly nodose, and it is defined above and below by raised lines which are slender and obscurely nodose. If the median lira is large and prominent, as it is in many specimens, it tends to give the periphery an angulated shape. On the other hand, because the median lira is small or for some other reason, the periphery may be strongly rounded instead of angular. As the lirae that bound the slitband resemble the secondary lirae of the lateral surface and

the median lira resembles the primary lirae the slitband is not as well differentiated as it is in many species, being recognizable chiefly by the deflection of the transverse lirae into lunettes, which, as they produce stout nodes upon the median lirae, to that extent disguise instead of distinguish it. The lunettes are strong and rather widely spaced—not quite so widely spaced as the transverse lirae on the lateral surface. On a few specimens the lunettes for some distance near the aperture are feebly developed—scarcely more than growth lines—and in crossing the median lira they produce scarcely more than crenulations. Farther back on the same volution, however, they are strong and nodose.

The markings of the lower surface do not differ materially from those of the lateral surface. The revolving lirae are generally a little more slender and more widely spaced and they are also more regular in size and in arrangement. They are somewhat more numerous (being 8 or 9 in number) but at the same time they cover a wider surface. In comparison with the lateral surface the transverse lirae are decidedly more subdued and more closely arranged, and they are more distinctly subordinate to the associated spiral lirae. The enlargements formed at the intersections are but small, sometimes scarcely appreciable except in the axial region where some of the spiral lirae (rarely more than 2 or 3) are strongly and conspicuously nodose. In direction the transverse lirae have a somewhat backward direction and a slightly sinuous course making close to the slitband a short and gentle convex curve, then a broad and gentle concave curve, and near the axis a second convex curve.

In the earliest volutions on which the sculpture has been observed, it appears to consist entirely of very fine spiral lirae—this refers, of course, to the region above the slitband which is the only part not concealed. Somewhat later transverse lirae become visible though at first they are much subordinate to the spiral ones; still later by a relative increase in strength they become nearly but not quite equal to them.

There are few species in our Carboniferous literature with which *P. aspera* can profitably be compared, those whose sculpture is somewhat similar being mostly much more depressed-conical in shape. *P. granulistriata*, however, is very similar in both shape and sculpture, so much so that selected specimens, though no two have been observed that were even essentially the same in character, might yet be classed as of the same species. The sculpture of *P. granulistriata*, however, is on the whole coarser than that of *P. aspera*, the nodes at the intersections of the decussating lirae are more rounded and prominent and the transverse lirae are less pronounced.

McCoy formation of Roth (Pennsylvanian); McCoy, Colorado (station 6714).

Pleurotomaria woolseyana, n. sp.

Figs. 26, 27.

Shell of medium size, subconical or subovate, somewhat turreted. Volutions about five in number. Spire moderately high with depressed sutures. Aperture subelliptical or slightly rhombic. Axis solid.

The external surface of the final volution is sharply differentiated into three zones—lateral, peripheral, and basal. The narrow peripheral zone

which contains the slitband occurs well below the mid-height. It is approximately parallel to the axis and is either gently concave, when it is defined by slender raised lines, or flattened, when it is defined by distinct angles. The broad lateral surface is moderately convex and declines more or less strongly from the suture. The broad lower surface is almost planate. It has a gentle downward obliquity from the periphery but is strongly upturned in the axial region and also, in some specimens more than in others, near the periphery.

The sculpture comprises spiral and transverse lirae. The spiral lirae occur on both the lateral and the basal surface; the transverse lirae only on the lateral surface. On the lateral surface the spiral lirae are rather strong and closely arranged; they are developed to the number of 10 or 12 and are commonly subequal, though they may irregularly alternate in size. The transverse lirae are apt to be somewhat weaker than the revolving lirae and somewhat finer and more closely arranged. The spiral series shows a gradual increase in scale from the suture to the periphery; the transverse series likewise shows a gradual increase in scale from above downward but also a diminution in strength. The points of intersection of these two series are reinforced as small but pronounced nodes which are distinctly aligned in spiral and transverse rows. Because of the weakening of the transverse lirae in their downward course, the transverse alignment is conspicuous over the upper part of the volution while the spiral alignment alone is distinct in the lowest rows—2 or 3 in number. Sometimes the lirae themselves are inconspicuous but the nodes which they form remain undiminished in strength and in the regularity of their alignment.

The lower surface is marked by revolving lirae, about 12 in number. These lirae contrast sharply with those of the lateral surface in being smooth instead of nodose; as a rule they are also somewhat stronger and more widely spaced. They become more slender and more closely arranged toward the axis. Very fine regular incremental lines are sometimes present and correspondingly fine crenulations are then formed on the revolving lirae; however, even these are rarely to be observed.

The markings of the peripheral zone are delicate and commonly obscure, and they appear to vary from specimen to specimen. The arrangement most often found consists of 3 or 4 equal, closely spaced, revolving lirae without appreciable cross-markings. On some specimens a line having the median position is larger than the rest, and on some only a single line, corresponding to this one, can be made out. The median lira, whether alone or accompanied by others, may be periodically enlarged into minute, beadlike nodes; for any other manifestation of transverse lines, however, one looks almost in vain. There is, however, convincing evidence, both from analogy and occasional observations, that the peripheral zone with its specialized sculpture is the site of the slitband.

The volutions embrace up to the lower border of the slitband, and as the volutions are more or less convex while the band is vertical in direction besides being more or less concave, the suture is correspondingly indented and the spire correspondingly turreted.

In the figured specimen the nodes above the slitband appear to be arranged in spiral lines only, especially the two lowest. Over the upper part of the volution the dual alignment is conspicuous. In fact, certain lights bring out a reversed alignment across the surface. The normal transverse alignment (from the suture downward and to the right) is not adequately shown

by the figure which also is on too small a scale to show the minute nodes on the median lira of the slitband.

P. woolseyana is related, though somewhat distantly, to *P. granulistriata*. It is much larger, the largest of my specimens being 11 millimeters in height and 9.5 millimeters in diameter. Meek and Worthen's species is only about half as large and it also seems to be more constant in its slender conical form. The surface markings of both are the same in general plan, but those of *P. woolseyana* are finer, especially in relation to the size of the shell, and more subdued; 10 to 12 revolving lirae occur on the upper surface as against 3 or 4 in *P. granulistriata*, the lirae on the under side being also more numerous. The lirae of the lower surface are in this species a little larger and more widely spaced than those on the upper, which is just the reverse of the condition described by Meek and Worthen. Furthermore, the slitband in *P. granulistriata* is marked by sharply defined lunettes and is occupied in large part by a single revolving lira that is strongly and somewhat coarsely nodose.

P. woolseyana is much more closely related to *P. millegranosa* besides occurring in the same fauna. The most pronounced difference perhaps is that the slitband in *P. millegranosa* regularly carries a single revolving line that is strongly nodose, whereas the slitband in *P. woolseyana* has from 1 to 4 revolving lines that are not nodose or are but partly so; this difference, however, is but a general tendency, not invariably pronounced. Again, in *P. millegranosa* the sculpture of the lateral surface is coarser, the nodes are larger, and their arrangement in spiral lines, more conspicuous—or at least an arrangement in transverse lines is less so.

Brentwood limestone member of the Bloyd shale (early Pennsylvanian); bank of stream about $1\frac{1}{4}$ miles south of Woolsey, Arkansas. Winslow quadrangle (station 2849).

Pleurotomaria millegranosa n. sp.
Figs. 28, 29.

Shell small, subconical, composed of 5 or 6 volutions. Height and width about equal. Suture depressed.

Final volution somewhat rhomboidal in section with the periphery well below the middle. The lateral surface is strongly oblique and gently convex, slightly prominent close to the suture; the lower surface is almost planate and almost horizontal but is strongly upturned to the axis. The lateral and lower surfaces meet in a rounded peripheral angle about two-thirds of the entire height of the volution below the suture. The peripheral angle is indented by the slitband which is defined by two slender sharp revolving lirae of equal size and prominence. The volutions embrace about to the lower boundary of the slitband which, rising sharply above the suture, gives the spire a slightly turreted shape.

The sculpture varies considerably, but that of the lateral surface in general terms consists of 7 to 9 revolving lirae surmounted by rounded nodes regularly spaced at about their own diameter. The lirae are on the whole equal in size and regular in arrangement, but they are commonly a little

finer and more closely arranged above, near the suture, and a little coarser and more widely spaced below, near the slitband. For a short distance below the suture the nodes have a transverse as well as a spiral arrangement.

The lower surface is marked by from 7 to 13 slender, sharply elevated revolving lirae separated by flattened interspaces. In contrast to those of the lateral surface, these lirae are smooth, devoid of nodes or even, as a rule, of crenulations. Toward the axis, they do not so much diminish in size as in spacing, the interspaces near the periphery being somewhat wider than the lirae, those near the axis somewhat narrower.

The slitband, as already described, is a narrow sulcus indenting the peripheral angle and defined by two slender lirae. These lirae are smooth and knife-edged. The upper one contrasts strongly with the nodose lirae just above; the lower one, on the contrary, rarely differs appreciably from the lirae of the lower surface except that it is so situated and directed as to make the lower surface appear to terminate there in a sharp angle. The slitband is regularly divided by a slender median lira formed of small, closely arranged nodes. Though resembling the lirae of the upper surface in its moniliform shape, this lira is more slender and more finely nodose.

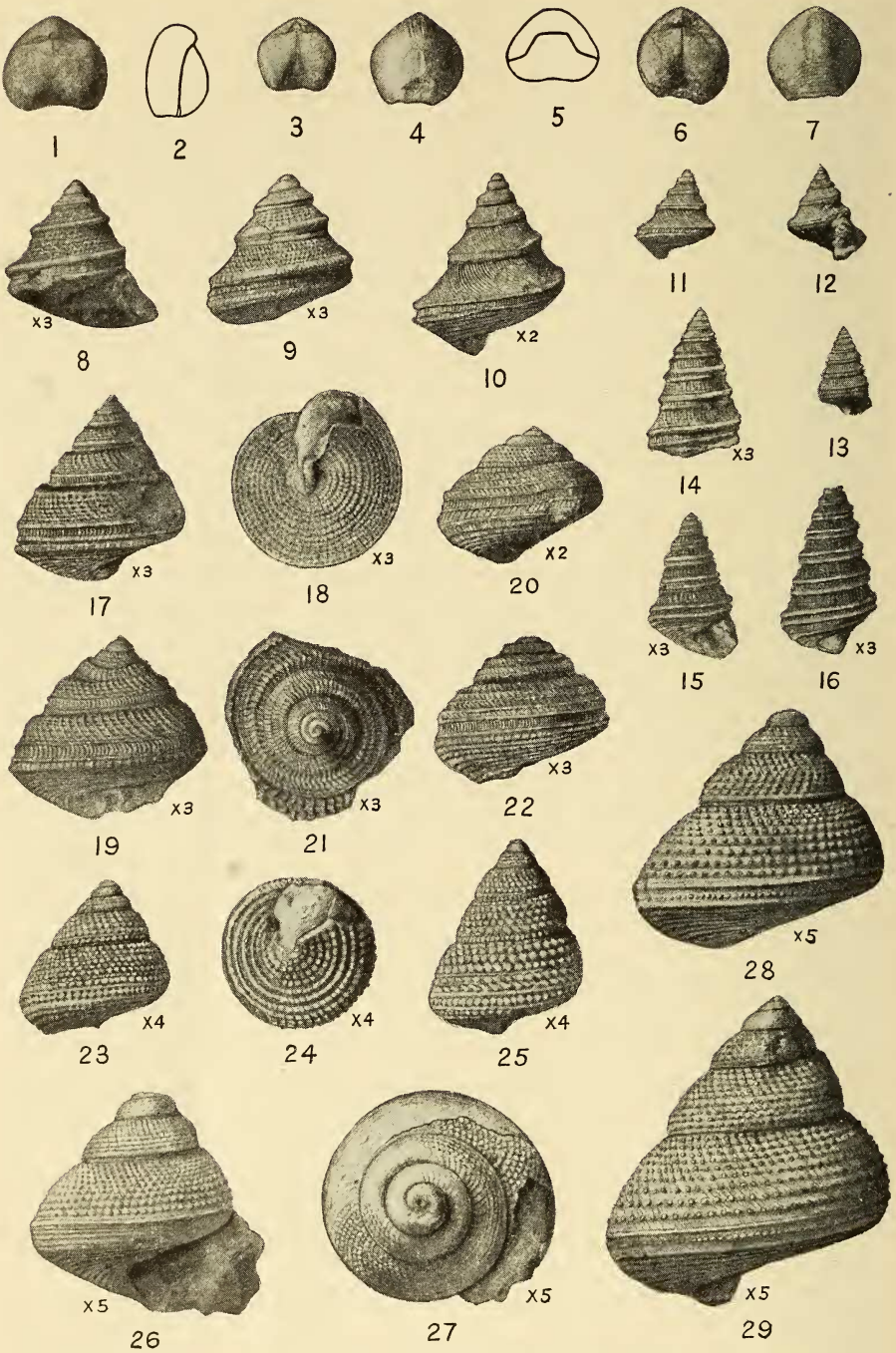
The axis is solid. There is no inner lip; instead, the surface of the final whorl within the aperture is smooth and depressed as if the shell had been removed by absorption.

The slit was probably shallow though it has not actually been observed. This inference is suggested by the fact that structure is not shown by specimens which appear to be but little broken at the aperture. Either the slit must have been short or the breakage greater than it appears to be.

This species is by no means rare and the numerous specimens examined show considerable variation. Shells have been referred here that differ notably both in the width of the spiral angle and in the shape of the constituent whorls. In some, the lateral and lower surfaces of the whorls are less arched than in others; the lateral surface may flare in the lower part with a prominent edge to the slitband below it; and rather commonly the lira that bounds the slitband above is a little stronger and more prominent than the one below it.

The relation between the lirae and the interspaces on the lateral surface is variable; the lirae may be relatively thick and the interspaces about equal to them or a trifle smaller; or the lira may be relatively slender and the interspaces correspondingly broad. Small accessory lirae may occur here and there in the interspaces, bringing the total number up to 12 or more in some instances. The size of the nodes and the size of the lirae vary pari passu. The accessory lirae have smaller nodes than the regular lirae and if extremely slender they may have no nodes at all. The slitband is sometimes distinguished not only in the ways mentioned, but also by being isolated, the interval between it and the lowest lira above being as wide as the slitband itself and much wider than the interval between any of the nodose lirae. On the other hand, this interval may be occupied by a slender accessory lira. The relation between the lirae and interspaces varies also on the lower surface, some specimens having slender lirae with relatively wide interspaces, others relatively thick lirae with narrow interspaces.

The nodose character of the revolving lirae is virtually due to slender transverse ridges developed at short and regular intervals which, on crossing the revolving lirae, greatly strengthen them. These transverse elements are rarely to be distinguished as ridges except below the suture; elsewhere they



Figs. 1–29.—For explanation see opposite page.

are almost without visible evidence save that which is furnished by the nodes. Consequently, the spiral arrangement of the nodes is conspicuous, the transverse arrangement readily overlooked. Nevertheless such an arrangement must be present if the nodes are formed in the manner indicated, and in fact, upon close observation, transverse rows can be distinguished, curved and backward sloping. Except near the suture and for occasional prolongations, very subdued, the transverse ridges do not appear elsewhere on the older volutions. They are suggested, it is true, by the nodes on the median lira of the slitband, but the slitband rarely shows any evidence, even obscurely, of the sharply defined lunettes characteristic of that part, whereas the lower surface commonly appears to lack even growth lines.

With well preserved specimens and with a favorable light, the nodes on the lateral surface are seen to have the form of arched scales rising obliquely toward the aperture and in general appearance they may be likened to a series of minute funnels issuing one from another. They appear to be produced by transverse lamellae that are extended and thickened where they cross the revolving lirae. On the same specimen, but with a change of light these projections look like well defined rounded nodes, and that is how they usually appear.

As the shell progressed toward maturity the volutions underwent a change both in shape and in sculpture. The immature whorls were essentially circular in section, but the later ones became flattened on the outer side obliquely and on the under side horizontally until they became more or less rhombic in section. The immature sculpture was characterized by a greater balance between the transverse and spiral markings. At a stage preceding that characterized by a mature type of sculpture the transverse lirae and the spiral lirae appear to have been of about equal strength. Not un-

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Description of figures

The figures on this plate are of natural size unless otherwise stated.

Figs. 1–7. *Cryptacanthia? robusta* n.sp. Different views of 4 cotypes. Figs. 1–2. Dorsal and side views of a large specimen somewhat worn down the middle of the pedicle valve. Fig. 3. Dorsal view of a small specimen. Fig. 4. Ventral view of another specimen. Figs. 5–7. Anterior, dorsal, and ventral view of a fairly complete specimen. Delaware Mountain formation, Culberson County, Texas (station 6452).

Figs. 8–9. *Pleurotomaria worthenioides* n.sp. Two views of the holotype, ×3. Brentwood limestone, Winslow quadrangle, Arkansas (station 3733).

Figs. 10–12. *Euconospira hermosana* n.sp. Three views of the holotype, figure 10 being ×2. McCoy formation of Roth, McCoy, Colorado (station 6714).

Figs. 13–16. *Pleurotomaria rockymontana* n.sp. Views of 4 cotypes. Figures 14–16 are ×3. McCoy formation of Roth, McCoy, Colorado (station 6714).

Figs. 17–19. *Orestas? reticulatus* n.sp. View of 2 of 4 cotypes. ×3. The specimen represented by figure 19 is not only crushed, but as drawn is somewhat tilted, giving a false impression of the configuration in several respects. The under side is really almost flat and almost horizontal, as in figure 17. McCoy formation of Roth, McCoy, Colorado (station 6714).

Figs. 20–22. *Orestes? quadrilineatus* n.sp. Views of 3 of 4 cotypes. Fig. 20 is ×2, the others ×3. McCoy formation of Roth, McCoy, Colorado (station 6714).

Figs. 23–25. *Pleurotomaria aspera* n.sp. Views of 2 of 4 cotypes. ×4. Figures 24 and 25 represent the same specimen. McCoy formation of Roth, McCoy, Colorado (station 6714).

Figs. 26, 27. *Pleurotomaria woolseyana*, n.sp. Views of 1 of 7 cotypes, ×5. The median lira of the slitband is marked by minute nodes, too small to be represented on the drawing. Brentwood limestone, Winslow quadrangle, Arkansas (station 2849).

Figs. 28, 29. *Pleurotomaria millegranosa* n.sp. Views of 2 of 7 cotypes, ×5. Brentwood limestone, Winslow quadrangle, Arkansas (figure 28, station 3733; figure 29, station 3662).

commonly the upper half of the volution will appear to be marked by transverse lirae rendered irregular or nodose by the spiral lirae while the lower half appears to be marked by spiral lirae rendered regularly nodose by the transverse lirae. At one stage, probably just prior to the stage just described, the surface is marked by smooth spiral lirae of considerable strength and at a stage still earlier by minute irregular spiral striations. The earliest stages were presumably smooth or marked only by incremental lines.

These specimens show a feature which they share with many other gastropods, but which cannot be accounted for in any acceptable way. I refer to small round openings or perforations which are obviously superficial as regards penetration, fairly uniform in size, and fairly regular in distribution. That is, although they are found only on certain specimens and on certain parts of others, they almost invariably occur on the tops of the nodes or on the crests of the lirae. They can hardly be attributed to a boring organism or on the other hand to abrasion. It is conceivable that they may be due to some peculiarity of structure or to some peculiarity of chemical composition (perhaps related to the pigments that produced color markings) and that variation in this feature was played upon by varying forces in process of fossilization. As this phenomenon is so common it is mentioned here only because it sometimes lends a fictitious appearance to those lirae of the lower surface which are described as smooth and even, but are in this way made to appear ragged or nodose.

P. millegranosa was found in considerable abundance at station 3662 and station 3733, and a single characteristic specimen was found at station 1996d. Elsewhere the species appears to be rare and the other specimens referred here are few, immature, and more or less ill-preserved. Their identification is correspondingly qualified.

Pleurotomaria millegranosa resembles Meek and Worthen's *P. granulistriata* from which, however, it differs considerably in several particulars. The whorls in *P. granulistriata* appear to be more regularly rounded and the lateral surface is traversed by only 3 or 4 revolving lines, whereas *P. millegranosa* has twice that number. The transverse lines which in both species help to produce the granules on the revolving lirae are in *P. granulistriata* more pronounced; in the present species the granules (except in young specimens) rarely show much transverse connection and are predominantly spiral in their arrangement. Furthermore in *P. millegranosa* the lower surface has somewhat more numerous revolving lirae and it is also without cross striae. These differences and others show clearly that *P. millegranosa* is a distinct species. It is also distinct from the one which I have called *Pleurotomaria woolseyana*, though an undoubted resemblance exists between them. The slitband in *P. millegranosa* is narrower and more sharply defined and it is traversed by a single lira which bears regular nodes instead of several smaller lirae which commonly are without them and the lateral surface is even less conspicuously marked by transverse lirae.

Brentwood limestone member of the Bloyd shale (early Pennsylvanian); S.W.$\frac{1}{4}$ sec. 27, T.13N., R.32W. (station 3733); up draw from Cove Creek, 3 miles north of Cold Spring, Arkansas (station 3662). Winslow quadrangle.